MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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The Rev. R. MAIN, President, in the Chair.

Walter Parsonson, Esq., Sheffield;
George Knott, Esq., Woodcroft, Cuckfield, Sussex;
Rev. H. Cooper Key, Stretton Rectory, Hereford; and
O. Pihl, Esq., Christiania, Sweden,

were balloted for and duly elected Fellows of the Society.

Account of Observations of the Total Solar Eclipse of 1860, *July* 18, *made at Hereña, near Miranda de Ebro; with a notice of the general proceedings of "The Himalaya Expedition for Observation of the Total Solar Eclipse."* By G. B. Airy, Esq., Astronomer Royal.

In placing before the Royal Astronomical Society an account of my observations of the Total Eclipse of the Sun, of 1860, July 18, it is not so much my own personal observations which I wish to convey, as an account of the general proceedings of a party who, I trust, will be distinguished in future times as associated under the title of "The Himalaya Expedition." And even of these I cannot profess, in this communication, to give the scientific observations. The number is far too great, (from persons either who sailed in the Himalaya, or who were connected with the expedition by friendly ties, I have already about sixty accounts); and the details too extensive. Moreover, in a subject where much of the value of the observations will depend on the comparison of different persons' observations, it may not improbably be found advantageous to break up each account, and to collect from all the different accounts; first, those parts which relate to one part of the phenomena, and

which will aptly form one large chapter; secondly, those which relate to another part of the phenomena, and which will form a second chapter; and so on. I trust to be able hereafter to lay before the Society a comparative account of the observations, framed, probably, on these general principles. Omitting, then, for the present, the details of observations of the mass of observers, I will first give a short account of the expedition generally, and will then subjoin a few words only on my own observations.

Having had the honour of an interview with the Duke of Somerset, First Lord of the Admiralty, on 1859, Nov. 15, I took occasion to call His Grace's attention to the approaching total eclipse, and to submit to his consideration the advantage of appropriating to the use of astronomers a ship, for their conveyance to and from the coast of Spain. Although no answer could then be given to this proposal, the reception of it was so far favourable that I was induced to speak of it, in communications to this Society, as an arrangement which might be expected. Finally, the noble screw-steamship Himalaya, commanded by Captain Seccombe, R.N., was appointed for this service.

In the meantime the Society had received several communications, of a most friendly and very important character, from Charles Vignoles, Esq., whose position as Engineer-in-Chief of the Tudela and Bilbao Railway (the whole of which was to be covered by the shadow of the totality) not only gave him a thorough knowledge of the country, its points favourable for observation, its climate, and its social resources, but also enabled him to employ his own official powers and to use his good offices with the Directors of the Railway, particularly with their Managing Director, Señor Cipriano de Montesino, for giving to astronomers the assistance of the staff of able engineers stationed at different points of the railway. Offers of assistance, of a similar kind, were made by Philip E. Sewell, Esq., Engineer-in-Chief of the Isabella Segunda Railway, extending southward from Santander, to Alar del Rey. These invitations, in addition to other considerations, sufficed to define the course of the expedition. It was arranged that the Himalaya should first touch at the roads of Bilbao, landing there a portion of the party (in which I was myself included) who relied principally on the kindness of Mr. Vignoles for guidance in the selection of stations, and for aids to reach them; and that she should then proceed to Santander to land the remainder of the party, who would receive much assistance from Mr. Sewell. The ship would then lie in the harbour of Santander, and after the completion of the observations she would receive the Santander party, again touch at Bilbao to receive the Bilbao party, and finally return to England.

Mr. Vignoles, and other persons well acquainted with the climate, had strongly insisted on the danger (from the fear of cloudy skies) of remaining in the Biscayan provinces, and

urged that a large proportion, at least, of the observers should cross the Cantabrian Pyrenees into the valley of the Ebro. This arrangement implied an addition of at least two days to the time to be spent in Spain before the eclipse, and as much after the eclipse. It was also thought important to allow sufficient time for the transport of the heavy apparatus to be used by Mr. De La Rue, and for the erection of the temporary buildings in which he proposed to mount it. After consideration of these and other points, the morning of July 7 was fixed for the sailing of the Himalaya from Plymouth Sound.

At an early time I had addressed Lord John Russell, Her Majesty's Principal Secretary of State for the Foreign Department, requesting his intercession with the Spanish Government for such a degree of relaxation of the Police and Custom-house regulations as would permit astronomers to enter Spain with facility and without the charge of duty on their apparatus. In the correspondence which followed, I received letters from His Excellency Don Xavier e Isturiz, Ambassador of the Spanish Government; from Don Antonio Aguilar, Principal of the Observatory of Madrid; and from Don F. de P. Marqua, Principal of the Observatory of San Fernando, Cadiz; and in all of these I was abundantly assured of the interest taken by the Spanish Government in the enterprise, and of their determination to withdraw, for the benefit of astronomers, all the customary arrangements of ports and frontiers, which give trouble and expense to travellers.

The Himalaya sailed from Plymouth Sound, as was arranged, on the morning of July 7. The weather was fine, and the navigation generally agreeable. And nothing will ever efface, from the minds of those who had the pleasure to share in this voyage, the recollections of the kindness and courtesy of Captain Seccombe, R.N., commanding the ship; Lieutenant (now Captain) Versturm, First Lieutenant; John Thompson, Esq., Master; and the other officers of the Himalaya. The table and other accommodations provided by the Admiralty were most liberal, and every arrangement of the ship most comfortable.

In some conferences, on the deck of the Himalaya, an attempt was made to divide among the observers the different classes of observation.

The high land of Cape Machicaco was made early in the morning of July 9, and the Himalaya dropped her anchor in the roads of Bilbao a few hours later. Mr. Vignoles, accompanied by the principal officers of Customs and Police, and other departments, came out in a small steamer to receive and welcome the Bilbao party. The baggage and instruments were nominally examined in transit; the examination consisting, in reality, of lifting the lid of one open box. No passport was examined. The following is (I believe) a list of the party who landed at Bilbao:—

G. B. Airy, assisted by Wilfrid Airy.
Rev. H. A. S. Atwood.
Joseph Beck, assisted by Walter Beck.
Joseph Bonomi.
Warren De La Rue, assisted by E. Beck, Mr. Beckley, Mr. Downes, Mr. Reynolds.
Francis Galton.
Professor Grant.
Charles Gray.
Captain Jacob.
Dr. M'Taggart.
Rev. J. S. Perowne.
J. G. Perry, accompanied by Professor Pole.
Rev. C. Pritchard, assisted by V. Fasel.
Russell Scott.
Otto Struve, assisted by M. Oom and M. Winnecke.
Rev. O. Vignoles.
John Wright.
Together with four ladies, namely Mrs. Airy, Mrs. O. Vignoles, Mademoiselle Struve, and Miss H. Airy.

The Himalaya then proceeded to Santander, and, on July 10, landed the following party:—

James Buckingham, assisted by W. Wray.
H. S. Ellis.
Professor Fearnley.
Rev. H. A. Goodwin.
R. F. Heath, assisted by J. Turner.
R. J. Hobbes.
W. Lassell.
M. Lindelöf.
Professor Lindhagen.
E. J. Lowe, accompanied by Rev. W. R. Almond and Mr. S. Morley.
Dr. Möller.
J. Stanistreet.
Professor Swan.

Of the Santander party I have at present no further account to give, and of the Bilbao party only the following. A kind reception from all parties awaited the astronomers on the Spanish land. The mayors of towns and villages, and the commandants of police, called on us and placed their powers at our disposal. On the day of the eclipse, the telegraphs were reserved for astronomical communications. But I am bound especially to say that the activity and entire self-devotion of Mr. Vignoles, his extensive private hospitality, and that of the gentlemen subordinate to him in the conduct of the Tudela and Bilbao Railway, contributed in a most important degree to the comfort of a large section of the observers, and to the success of their observations. To Mr. Bartlett, also, Resident Con-

tractor for the Railway works, we are indebted for much assistance.

Mr. Vignoles without delay despatched Mr. De La Rue's heavy instruments, &c., to the station which had been selected for him at Riva Bellosa, near Miranda. As early as possible the party were assembled at the offices of the Tudela and Bilbao Railway, and there, under the instructions of Mr. Vignoles and M. Montesino, a selection of stations was made. Omitting from this time allusion to other observers, the station allotted to M. Struve, M. Oom, M. Winnecke, and my own family party, was Pobes.* This is a very small and secluded village on the river Bayas, about two miles south of the remarkable defile of Tetches, where the Bayas issues from the Cantabrian Pyrenees. It is accessible by a good road in the direction of Orduña, Espejo, and Salinas (Anaña), as also by Vitoria and Nanclares. The Bayas, in its descent towards the Ebro, at the distance of little more than two miles, enters another defile, which is bordered on the eastern side by the hill above Hereña (called, I believe, St. Lorenzo), to be further mentioned in this account. The view from Pobes is therefore bounded on all sides by mountains, with the exception of a lateral depression on the eastern side of the valley, south of the Morillas hill, through which the mountains of the lower Ebro are seen. The church of Pobes stands on a steep knoll, perhaps 80 feet above the plain, and the churchyard surrounding it commands a very beautiful prospect.

At Pobes we were all placed under the hospitable care of Christopher Bennison, Esq., Superintendent of an extensive section of the Railway. And none of us will forget the kindness and the attention to all our wants, social and scientific, which we then experienced.

I arrived at Pobes, from Orduña, on the afternoon of Saturday July 14. On the northern side of the mountains the day had been dull and foggy, but on the south side the weather was extremely fine. I found my instruments arrived, and found Messrs. Struve, Oom, and Winnecke, engaged in astronomical observations for the determination of latitude and time. Their station for this purpose was a threshing-floor close to the churchyard. But I found that they had already selected points on the hills near Pobes, on the right bank of the Bayas, as stations for the observation of the eclipse. On viewing the country I had no hesitation in fixing on the hill above Hereña, on the left bank of the Bayas, as a very desirable post for myself.

I employed a part of the evening in endeavouring to judge (by memory) of the degree of darkness in a total eclipse. For this purpose I lighted a wax-candle, such as I had used in 1842 and 1851, and placed it on the parapet of the churchyard; and

* Pobes was the scene of some military movements immediately before the battle of Vitoria.

then, correcting my eye by its light, I remarked the time when, as I thought, the darkness appeared equal to that in the totality of 1851. It was about $8^h\ 30^m$ Greenwich mean solar time. Computing from this the position of the sun, it was about $7°\ 7'$ below the horizon. The evening was splendidly fine.

The next day, Sunday July 15, was magnificent. I went to the hill above Hereña, and found that it entirely satisfied my wishes. The point which I selected was the extreme eastern point, the highest part of the hill. The view of mountain and valley from this point is singularly grand. In the north-west direction, from which side the darkness would approach, the vision is limited at a few miles distance by the Pyrenees; but on the south-east side, in the direction of the retiring shadow, it extends across the Royal Road (from Vitoria to Miranda) and across and along the lower Ebro, to a very great distance. The south side of the hill is a bushy slope; the north side is a low crag of puddingstone, succeeded by a narrow flat and a talus, on which are numerous fine trees of the ilex, so common in that country, many of whose tops rise above the crag; and I could reckon with certainty on sheltering my telescope from any wind.

On the evening of July 15, finger-formed clouds began to show themselves in the north sky, and very soon there burst forth a thunder-and-lightning storm of great violence, which lasted all night. On July 16 and 17, the weather appeared completely changed. The wind blew from the north and was very cold; the near mountains were clouded very low; the distant mountains were invisible; the sun was not seen. The last-mentioned circumstance was unfortunate for me. I had prepared a telescope (constructed as I had previously explained to the Society) with a system of wires engraved on glass, containing, as an essential part, a square defined by crossing lines, within which square the image of the moon was to be brought. Pressure of business had prevented me from making many trials of this apparatus at Greenwich, but I had found that the dimensions of the square were a little too large for the sun, and I trusted that they would exactly correspond to the moon. In fact, they were a very little too large, and delicate manipulation was required for maintaining the moon exactly in the centre. I had relied on the climate of Spain for permitting me to acquire the necessary practice, when the sun should be near its meridian height on the two days preceding the eclipse; but in this hope I was totally deceived.

The morning of July 18 was cloudy; but distant mountains began to show themselves, and the aspect of the sky was improving. With the three companions of my own family whom I have mentioned, with Mr. Stead, one of the staff of railway engineers, and with nine men to carry instruments, I proceeded from Pobes to Hereña and up the hill. The weather steadily

improved, till before the eclipse began it was splendidly fine; a few clouds rather low in the south being all that was left of the late murkiness. My own telescope ($3\frac{3}{4}$-inch aperture, 46 focal length, on tripod stand) was placed a few yards west of the end of the hill; the power used was about 50. The telescope used by Wilfrid Airy ($3\frac{3}{4}$-inch aperture, 36 focal length, on tripod stand) was placed about twenty yards further west; the power used was about 100. I had a duplex watch, Molyneux 1007, beating $\frac{2}{5}$ seconds; Wilfrid Airy had a lever watch, Dent, beating $\frac{1}{4}$ seconds. The rest of the party had no telescopes or trustworthy watches.

Before giving the observations themselves, I will premise some numerical elements necessary for their reduction.

In comparing the observations made at numerous stations, it is evidently desirable to refer all the stations to a common system of geographical co-ordinates; and much of the clearness of our results may depend on the due choice of the system of co-ordinates. Now it appears evident that we want, not terrestrial longitudes and latitudes, but something which will show the relation of each observation to the following two elements,—first, the absolute time of the phenomenon; secondly, the nearest distance of the sun's centre from the moon's centre as seen at the place of observation. These elements are well connected with co-ordinates, of which the abscissa is measured along the central line of shadows, and the ordinate is measured along a line of simultaneous centrality of totality. The lines of which I speak are drawn upon Mr. Vignoles' map. I have therefore taken the measures from that map, using the minute of latitude as the unit of measure. For the zero of abscissa I have taken the western border of the map. The co-ordinates of Pobes, thus defined, are nearly,—

Abscissa 152; Ordinate 19 N.E.

A solar chronometer, Molyneux 2184, was carried from Greenwich. It was usually in the custody of M. Struve, and was undoubtedly treated with all possible care. Comparisons of its indications with Greenwich mean solar time were made before going and after returning, of which the following may here suffice:—

Molyneux 2184, slow on Greenwich Mean Solar Time:

			h	m	s
1860,	June	23	0	2	5·0
	July	5	0	2	39·0
	July	30	0	4	2·4
	August	11	0	4	36·4

The mean daily rates in the three several groups are $2^s{\cdot}83$, $3^s{\cdot}34$, and $2^s{\cdot}83$. The agreement of these gives great confidence

in the uniformity of rate from July 5 to July 30. Adopting $3^{s}\cdot34$, we have the following results:—

Molyneux 2184, slow on Greenwich Mean Solar Time:

	h	m s
June 17	0	3 19·1
18	0	3 22·4
19	0	3 25·8

I am informed by M. Winnecke that the errors of the chronometer on Pobes mean solar time (as found by astronomical observation) at these epochs were $8^{m}\ 18^{s}\cdot0$, $8^{m}\ 15^{s}\cdot1$, $8^{m}\ 12^{s}\cdot1$, fast. These give for the longitude of the threshing-floor near the churchyard of Pobes $11^{m}\ 37^{s}\cdot1$, $11^{m}\ 37^{s}\cdot5$, $11^{m}\ 37^{s}\cdot9$. Its latitude was found to be 42° 48′ 5″.

Again we have,

Molyneux 2184, slow on Greenwich Mean Solar Time:

	h	m s
June 17	22	3 22·1
18	22	3 25·5

At these times, Molyneux 1007 was faster by $2^{m}\ 46^{s}\cdot4$ and $2^{m}\ 52^{s}\cdot5$; and Dent was slower by $15^{m}\ 56^{s}\cdot0$ and $17^{m}\ 9^{s}\cdot5$. From these we find with sufficient approximation, at July 18, 2^{h} to 4^{h},

	m s
Molyneux 1007, slow on Greenwich Mean Solar Time	0 35·1
Dent slow	19 31
to	19 37

Finally, as it was my intention to refer angles to wires in the telescope having a definite relation to the vertical, it was necessary to ascertain the angle made by the vertical with the astronomical meridian. On calculation it appears that the angles were,

	h m		° ′
At	2 50	Greenwich Mean Solar Time	46 39
	3 0	... ...	47 41
	3 10	... ...	48 35

During the $3\frac{1}{3}^{m}$ of totality, this angle therefore changed by about 19′; a quantity smaller than I could answer for in my observations, but which in more delicate measures ought not to be omitted.

I shall now proceed with my observations.

For observations of time, I commenced counting the $\frac{2}{5}$ beats of my watch at some decade of seconds, and counted up to 25 ($=10^{s}$), after which I again began counting. Thus I observed the first contact at $1^{h}\ 47^{m}\ 30^{s}$ of Molyneux 1007. My eye, however, was directed (in consequence, as I have since found,

of an error in the position of my wires) to a point on the sun's limb about 5° too high; and in consequence I did not perceive the very first contact. I think that it had taken place about 4^s before the time noted. This gives for watch-time $1^h\ 47^m\ 26^s$, or for Greenwich mean solar time $1^h\ 48^m\ 1^s$; which I consider very exact.

On the progress of the eclipse I have nothing to remark, except that I thought the singular darkening of the landscape, whose character is peculiar to an eclipse, to be sadder than usual. The cause of this peculiar character I conceive to be, the diminution of light on the higher strata of air. When the sun is heavily clouded, still the upper atmosphere is brilliantly illuminated, and the diffused light which comes from it is agreeable to the eye. But when the sun is partially eclipsed, the illumination of the atmosphere for many miles round is also diminished, and the eye is oppressed by the absence of the light which usually comes from it.

I had a wax-candle lighted in a lantern, as I have had at preceding total eclipses. Correcting the appreciations of my eye by reference to this, I found that the darkness of the approaching totality was much less striking than in the eclipses of 1842 and 1851. In my anxiety to lose nothing at the telescope I did not see the approach of the dark shadow through the air; but, from what I afterwards saw of its retreat, I am sure that it must have been very awful.

At $2^h\ 59^m\ 30^s{\cdot}0$ of my watch I commenced counting the beats, holding the watch to my ear, and recommencing the counting at the end of 25 beats. When, from the narrowness of the sun's lune, I judged that the totality would occur in ten or fifteen seconds, I withdrew the graduated coloured glass. To my infinite astonishment, while the white sun was still shining brilliantly, I saw in great splendour two red prominences (possibly more than two were visible) and one double floating red cloud. I am not certain whether the red sierra was then visible, or whether it became visible after the white disk had disappeared. But, before the white disk had disappeared, the white corona formed round the moon, I think all at once; and the moon was seen complete, with dazzling sun, brilliant corona, and brilliant prominences. The intensity of light in the corona and prominences was not much increased at the total disappearance of the sun.

The co-existence of all these lights really introduced much confusion in the observation of the time of formation of totality. I found myself counting the beats of my watch up to 45, and I set down the time of totality as $2^h\ 59^m\ 30^s + 45$ beats. But I was afterwards under the impression, and now fully believe, that I had passed one counting of 25 beats; so that the register ought to have been $2^h\ 59^m\ 30^s + 70$ beats. This makes the time $2^h\ 59^m\ 58^s$ of my watch, or $3^h\ 0^m\ 33^s$ Greenwich mean solar time.

In a former communication to the Society I stated my intention to use a system of wires embodying the following conditions: 1. That there should be a square, pretty exactly containing the moon; 2. That there should be a system of 12 crossing lines, or 24 radii passing through the centre of the square, and inclined each to its neighbour at an angle of 15°; 3. That two of these crossing lines should be stronger than the rest, one approximately in the direction in which it was found (by calculation) that the moon would apparently cross the sun, the other in the direction normal to that crossing motion. And I proposed to observe the angular position of any prominences which might be near to the normal line. Mr. James Simms had furnished me with a reflecting eye-piece taking a definite position (as to angular rotation) in the telescope, and bearing such a system of lines etched on the reflecting prism; the position of the strong normal line being a few degrees in error. On bringing the moon into the square I found that there were two appearances which precisely corresponded to my wishes; one a prominence exactly 15° to the apparent left (or on the radius whose angle, measuring from the upper normal in direction of watch-hand-motion, is 345°); the other the double floating cloud, exactly 15° to the apparent right; both being bisected by the radial lines. A third large and conspicuous prominence more to the left, at perhaps 300°, I merely saw with a single glance. There might be others which I did not remark.

[I may take this opportunity of stating that the colour of these appearances was not identical with that which I saw both in 1842 and 1851. The quality of the colour was precisely the same (full blush-red, or nearly lake), but it was diluted with white, and more diluted at the root of the prominences close to the moon's limb than in the most elevated points.]

I proceeded as soon as I could with my measures (to be given below). About the middle of the totality I ceased for a while, in order to view the prospect with the naked eye. The general light appeared to me much greater than in the eclipses of 1842 and 1851 (one cloudy, the other hazy), perhaps ten times as great; I believe that I could have read a chronometer-face at the distance of 12 inches; nevertheless, it was not easy to walk where the ground was in the least uneven, and much attention to the footing was necessary. The outlines of the mountains were clear, but all distances were totally lost; they were in fact an undivided mass of black, to within a small distance of the spectator. Above these, to the height perhaps of six or eight degrees, and especially remarkable on the north side, was a brilliant yellow or orange sky, without any trace of the lovely blush which I saw in 1851. Higher still the sky was moderately dark, but not so dark as in the former eclipses. The corona gave a considerable body of light; I did not

remark, either by eye-view or by telescopic view, any thing annular in its structure; it appeared to me to resemble, with some irregularities (as I stated in 1851), the ornament round a compass card. But the thing which most struck me was the great brilliancy of *Jupiter* and *Procyon* so near to the sun. It was impossible that they could have been seen at all, except under the circumstance of total absence of illumination on that part of the atmosphere through which their light passed.

I returned to my measures, but I was soon surprised by the appearance of the scarlet sierra announcing the approach of the sun's limb. It disappointed me, for I had reckoned on a much longer time. All our party who were aware of the predicted duration fully believed that it must have been very erroneous. How the time had passed I cannot tell. The sun at length appeared, extinguishing the sierra, but the prominence and cloud remained visible, and my last measures were taken after reappearance. The prominence, &c., were then rapidly fading, and I quitted the telescope, not without the feeling that I had not done all that I had intended or hoped to do.

I looked around me, and in the southeast direction and for some time, perhaps ten seconds, I saw nothing remarkable in the atmosphere. About that time, as the light about me grew stronger, the darkness in the south-west attracted attention, and before long it looked as if the very air on that side was composed of blackness and opacity. The mountains along the Ebro were totally lost. A full half-minute passed, I think, before the darkness had so far diminished as not to produce the dominating impression of the scene.

My companions saw nine celestial objects, eight of which were identified by means of Mr. Hind's chart, and the ninth by our knowledge of its position. They appeared to be (using Mr. Hind's numbers of reference), 2 *Regulus*, 3 *Saturn*, 4 *Mercury*, 6 *Procyon*, 7 *Jupiter*, 8 *Venus*, 9 *Pollux* or 11 *Castor*, (not quite certain), 13 *Capella*, and *Arcturus*. *Sirius* and *α Orionis* were hidden by clouds.

I now proceed with my measures. I must premise that I used a reflecting eyepiece, and therefore my image was erect with regard to up and down, and inverted with regard to right and left. My angular measures, which were made in the direction of watch-hand-motion, must be interpreted as made in the opposite direction. The strong normal line which was my zero of angle, was inclined, its upper part apparently to the left or really to the right, by about $9\frac{1}{2}^\circ$, and that quantity must be subtracted from all measures in order to refer them to the upper vertical. Finally, the angle $47^\circ\ 50'$ (found above) must be added (making the entire correction $38^\circ\ 20'$ additive) in order to refer the measures to the north meridian. The following are the measures as recorded; the angles being expressed by number of wire (which is to be multiplied by 15°) and by fractions of intervals of wires (or fractions of 15°). The

number of observations, it is conceived, divide the time into nearly equal parts:—

	Prominence.	Cloud.
No. 1	Measure lost in observing the time.	
2	$23^d + \frac{1}{6}$ interval.	$1^{st} + \frac{1}{6}$ interval.
3	$23^d - \frac{1}{5}$	$1^{st} + \frac{1}{5}$
4	Measure lost in quitting the telescope.	
5	Measure lost in quitting the telescope.	
6	$23^d - \frac{1}{5}$	$1^{st} + \frac{1}{5}$
7	$23^d + 0$	1^{st} + very little.

or the angles from north meridian, measured in the direction opposite to watch-hand-motion, are,

	Prominence.	Cloud.
	° ′	° ′
No. 1	...	...
2	25 50	55 50
3	20 20	56 20
4	...	...
5	...	...
6	20 20	56 20
7	23 20	53 20+

I left the telescope with the impression that the angles here measured had decidedly and distinctly decreased; and so, on the whole, it appears from the numbers, but not incontrovertibly. I wish that I had been provided with better means for delicate motion of the telescope than the rack-and-pinions of the steadying rods.

The end of the eclipse was at $4^h\,9^m\,14^s$ by my watch, or $4^h\,9^m\,49^s$ Greenwich mean solar time, pretty good.

Perhaps the following remarks on the progress made in the observation of successive eclipses may not be without value:—

In 1842, I, with all the rest of the astronomical world, was taken by surprise with the appearance of red projections. In 1851, various important observations of the elevations of projections were made: I cite M. O. Struve's micrometical measures as the most valuable, and I should be glad if my own general observations of disappearance on one side and non-appearance on the other side were thought useful. One observer (I think not more) obtained a good measure of angular position. In succeeding observations which have been made in different parts of the earth, I think that no novelty has been introduced. In 1860 we have got not only good angular posi-

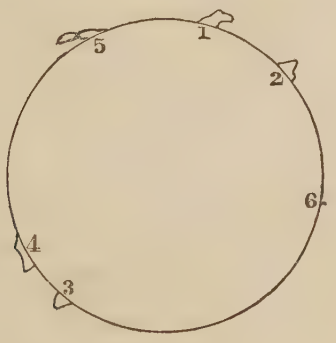
tions, but also fair attempts at measure of change of angle; and this will be seen more distinctly when the results deducible from Mr. De La Rue's photographs shall be published.

It is scarcely possible that I should observe a fourth total eclipse, and I can therefore only offer to future observers the advice upon which I should have acted myself. Whatever be the trouble and expense, and however small the chance of success in the observation, *use a good steady equatoreal, driven by good clockwork, and having easy transversal adjustments for the wire-frame.* With the system of wires that I have used (and which is described in the *Monthly Notices* for 1860, March 9, pp. 187, 188) I am well satisfied.

I extract the following notices from the accounts of my companions.

Wilfrid Airy observed the commencement of totality at $2^h\ 40^m\ 1^s$ by his watch, with the remark that, in consequence of a want of correspondence between the minute-hand and the second-hand, there might be an apparent error of 1^m. The application of the reduction computed above gives for the equivalent in Greenwich mean solar time, $2^h\ 59^m\ 35^s$; which, as compared with my observation, appears to be 1^m too small, but in other respects agrees closely.

By one of those inadvertencies which oppressed almost every observer during the excitement of the eclipse, Wilfrid Airy forgot to withdraw the coloured glass from the eye-piece, and actually observed the red prominences through it. This must be borne in mind as qualifying some of the statements that follow. "As soon as the totality commenced, the red prominences became visible, but I did not observe them before the totality. I did not notice the corona at all through the



telescope. The appearance and position of the prominences were as follows:—[the drawing, from the reversed image, being again reversed here to form a correct image.]

"Prominences 1, 2, 3 seemed to appear all at the same

moment; and 4 might have appeared also at the same time, but I did not notice it so soon. Prominence 5 did not appear till after the others, and was at first extremely hazy, but gradually thickened as the moon passed on. Prominence 4 disappeared about 1^m after the formation of totality, and I did not see it again. After the sun had burst forth, I noticed a prominence which would have been somewhere about 6; and this, as well as 1 and 2, I could see 2^m after the sun had reappeared. (I did not notice 6 before the sun reappeared, because I had left the telescope.) The colour of the prominences was a bright rose-colour, and 4 was brighter than 1, 2, and 3. Prominence 5 was lighter a good deal than the others.

"The stars that I noticed were *Jupiter*, *Mercury*, *Regulus*, *Saturn*, and *Arcturus*. *Arcturus* was bright. I saw no stars to the west of the sun."

[1 and 5 are the two objects whose positions I measured. It appears that Wilfrid Airy saw 5 as a prominence; whereas I, and also Mrs. Airy, who looked into my telescope, saw it as a floating cloud. 2 is the other prominence, which I saw in a glance.]

Wilfrid Airy saw the termination of eclipse at $3^h\ 50^m\ 4\frac{1}{2}^s$ by his watch, or $4^h\ 9^m\ 41^s$ Greenwich mean solar time, with the same caution as to possible error of 1^m.

From Mrs. Airy's notes I extract the following:—

"At last [some time after commencement] the light began to be sobered, like that of a summer evening, and soon a gloominess began gradually to creep over the whole scene, as if a storm were coming on. The southern mountains beyond the Ebro began to stand up strangely black. Then a sickly green hue began to creep over the whole nearer landscape. A peculiarly mournful sighing wind, cold and strong, began to rise as if from among the large old trees beneath us on the north side of the hill; and, looking down among them from the edge above, their dark green masses became every moment of a deeper green tinge, while the white old trunks gleamed whiter still. The butterflies disappeared, but the swifts continued on the wing. These appearances grew more and more intense, and all 'instructions' were totally forgotten in the excitement of the moment. It became very cold, and I was glad to wrap myself up in a large Scotch plaid. . . . The crescent diminished to a thread, the gloom everywhere intense. I was particularly struck with the moaning of the wind among the old forest-trees beneath me. The swifts had now disappeared. A deeper gloom filled the sky in the north-west, and came sweeping rapidly on. The moment of totality had come: the whole air was at once filled with darkness, yet it was darkness through which mountain and valley could be distinctly seen. To me it seemed as if we were in the midst of a streaky shower of smoke or fine dust, which, however, was perfectly clear, and which

could not be felt. It was only for a moment that I was struck with this appearance sweeping along the valley between us and the northern hills. The range of southern hills was of an inky black, while the sky beyond them was an intense golden orange. I have often seen a similar, though much fainter, effect in watching a fine summer sunset from the Greenwich Observatory through the smoke of London, when the air has been dry and the smoke very thin. These glorious colours were quite a new feature to me, for at the eclipse of 1842 the sky was entirely clouded. My shadow on the ground was quite black and sharp: the effect was like that of clearest moonlight. I could see the whole country, but I had to stoop in order to see my footing among the stones and shrubs. At the critical moment I forgot to remove the dark glass from my eye, and thus lost what I remember to have been the most striking phase of the whole phenomenon on the former occasion, viz. the starting out of the corona on the right side before the last thread-like crescent of the sun had disappeared on the left side of the moon. On that occasion, however (1842), it was a narrow fringe or border round the moon of soft light, of a uniform breadth, and slightly beaming texture, soon graduating into the darkness outside; while now it was a bright radiating glory of much wider extent, and its appearance made very singular from the projection of four or five brilliant beams at about equal intervals, far beyond the width of all the rest. I saw three bright stars near the sun; I could not, with the unarmed eye, see the red prominences. I looked for a few seconds in the telescope, and then I did see two of these wonderful appearances, but so faint in comparison with those of 1842 that for a moment I did not recognise them. One was a floating cloud, quite separate from and suspended over the upper edge of the moon, nearly divided into two parts by an indent below, of so pale a colour that at first it seemed almost white; but as I looked at it more steadily I perceived that it was of a pale rose-colour, the colour deepest against the upper edge, which was well defined, and becoming gradually paler to the lower indented edge. The other was lower down the edge of the left side of the moon, and not separated from it, but rising from it like those of 1842—a broad cone, cloven at the top; its colour was pale, like the other, and, like the other, it had a cloudlike and not a solid appearance."

At the reappearance of the sun, "We saw the dark shadow distinctly sweeping away along the valley to the south-east, a path of darkness, and the clear daylight breaking out behind it."

We descended from our hill-station, and on our way to Pobes we had the satisfaction of learning that M. Struve had been successful in his observations; and in no long time we were gratified by the intelligence that Mr. De La Rue's photographic operations during the totality had entirely answered to

his wishes. On July 20, I had the pleasure of visiting Mr. De La Rue at his station at Riva Bellosa; and, in admiring his observing establishment, I was much struck with the importance of his elaborate preliminary arrangements, in providing a first-class instrument, and carefully training his assistants; to which preparations his success is entirely to be attributed. On July 21, I, with my party, quitted the house of our most hospitable friend Mr. Bennison, for Vitoria, where I had the advantage of meeting Professor Mädler and M. Hermann Goldschmidt. I received here a telegraphic invitation from the Spanish Government, conveyed personally by the Secretary of the Governor of Viscaya, to join an Eclipse Congress at Madrid: the distance, however, and the pressure of home engagements, made it impossible for me to accept it. On July 22, we were again welcomed by our unwearied friend Mr. Vignoles, at Bilbao.

At our landing from the Himalaya, on July 9, it had been arranged that the ship should leave Santander for her return on the evening of July 23, and leave Bilbao on July 24. It now appeared, however, that the great festival of St. Jago, the patron saint of Spain, occurring on July 25, was to be celebrated by a bull-fight at Santander. In order to show our respect to a people from whom we had received so many marks of kindness, as well as to secure a longer time for collecting instruments, &c., the ship, at my request, was detained at Santander till the night of July 25, by which time all the Santander party had come on board. She lay the whole of July 26 in the roads of Bilbao, visited by many of the inhabitants. The Bilbao observers joined on that evening, and the vessel sailed immediately. We had left a few of our party, who proposed to return by land; their places were occupied by Mr. Vignoles, M. Montesino, Professor Chevalier, Mr. Wilson, and Professor von Weyer.

Many were the accounts of success and of misfortune to be told. It was matter of universal sorrow that the best friend of the expedition, Mr. Vignoles, had failed to see the eclipse. The Bilbao party had, for the most part, been successful; the Santander party, for the most part, were unsuccessful. Among these we were sorry to learn that our respected Fellow, Mr. Lassell, was to be numbered. After a most agreeable voyage, we anchored at Spithead about 4 P.M. on July 28, and landed in time for the railway-train which reached London on the evening of that day.

An account of the phenomena of the total eclipse as observed, under very favourable circumstances, at Burgos, was received from T. C. Janson.

Eclipse of the Sun, July 18, 1860. Observed at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

Observer.	Mean Solar Time of Observation. First Contact. h m s	Last Contact. h m s
M.	1 39 26·4 (*a*)	3 54 2·8 (*b*)
G.	1 39 30 (*c*)	3 53 57 (*d*)
D.	1 39 30·0 (*e*)	3 54 6·7 (*f*)
E.	1 39 34·0 (*g*)	3 54 1·0
J. C.	1 39 24·6 (*h*)	3 54 7·2 (*i*)

(*a*), (*h*), The time noted is that at which the sun's limb was first indented by a prominence in the moon. (*b*), (*f*), (*i*), Satisfactory. (*c*), Considered within a second of the truth. (*d*), Not so accurate as the observation of the first contact. (*e*), The moon's limb very mountainous at the point of contact. (*g*), Two or three seconds previously to the time noted, the sun's limb was indented by two prominences.

The initials M., G., D., E., and J. C., are those of Mr. Main, Mr. Glaisher, Mr. Dunkin, Mr. Ellis, and Mr. Carpenter.

The following accounts of the Eclipse, as observed in England, have also been received:—

Eclipse of the Sun, July 18, 1860.

Observed at Greenwich Hospital, by John Riddle, Esq.

The eclipse had commenced some seconds before it was observed at $1^h\ 39^m\ 55^s$.

The approach of the moon's limb to the spots marked in the diagram was well marked; the observations remarkably satisfactory.

Spot.	h m s
No. 2. The first with which the limb came in contact, disappeared at	1 53 47·5
No. 3. First contact with large spot in Group A	1 55 4
No. 4. Extremity of large spot disappeared	1 55 37
No. 5. Disappearance of spot	1 56 36
No. 6. Final disappearance of penumbra	1 56 43
No. 7. Disappeared at	2 1 43
No. 8. ,, ...	2 2 6·5
No. 9. ,, ...	2 2 25
No. 10. Well-defined small spot	2 6 24·5
No. 11. ,, ,, ...	2 25 15·5

A faint group followed, but offered no salient points for observation with the telescope employed.

No. 12 is a large double spot with a well-defined penumbra. Observed in the following order:—

	h	m	s
1. Penumbra, 1st contact	2	36	13·5
2. 1st contact with spot	2	36	30·5
3. Middle space reached	2	36	38·5
4. Extremity of spot disappeared	2	36	56

Next came the small spot marked

	h	m	s
No. 13.	2	37	35·5

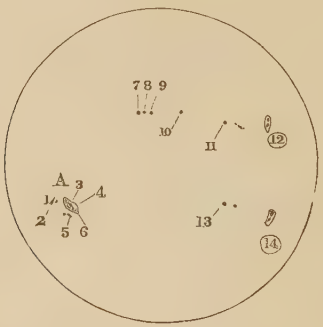
The following small spot was lost.

The larger group marked No. 14 was admirably well defined and observed as follows:—

	h	m	s
1. First contact with penumbra	2	44	40
2. First contact, upper spot	2	45	4
3. Spot disappeared ...	2	45	17·5
4. First contact, lower spot	2	45	33
5. Spot disappeared ...	2	45	45·5
6. Penumbra	2	45	52·5

The reappearances of the spots were confined to the complete reappearance of Group A at $3^h\ 0^m\ 32^s$, observed by Mr. Mugridge; and spot No. 10 at $3^h\ 16^m\ 38^s{\cdot}5$.

Telescope 2 ft. 8 in.; aperture 2·6 in.; power 40.



Sketch of the Spots on the Sun during the Eclipse of the Sun, July 18, 1860.

Greenwich Hospital, July 18, 1860.

Observed at Greenwich, by Rev. Geo. Fisher, M.A. F.R.S.

1. Sextant measures and distances of cusps.
2. Breadth of illumined portion of solar disk at right angles to the line of cusps.
3. Times of commencement and end of eclipse.

Time, Chronometer. h m s	Dist. of Cusps. ′ ″	Time, Chronometer. h m s	Dist. of Cusps. ′ ″
9 46 9	23 15	10 33 17	31 35
9 47 11	23 20	10 35 20	31 25
9 48 52	25 15	10 40 52	31 10
9 50 21	26 15	10 42 8	32 0
9 55 46	26 30	10 43 10	31 15
9 57 1	26 50	10 44 12	32 10
9 58 12	26 55	10 45 10	31 10
9 59 25	27 15	10 55 47	30 15
10 4 54	29 5	10 57 11	30 10
10 6 3	29 30	10 58 25	30 20
10 7 1	28 45	10 59 27	30 30
10 9 0	29 15	11 4 40	29 20
10 14 13	30 20	11 5 52	29 5
10 15 30	30 30	11 7 11	28 15
10 17 37	30 30	11 27 37	19 30
10 22 32	30 30	11 28 55	18 35
10 24 18	31 15	11 30 0	18 20
10 26 17	31 15	11 35 20	13 20
10 27 16	32 0	11 36 41	13 30
10 30 30	31 55	11 37 26	12 45
10 31 57	31 25		

Time, Chronometer. h m s	Greatest Breadth of Illumined Portion of Disk. ′ ″	Time, Chronometer. h m s	Greatest Breadth of Illumined Portion of Disk. ′ ″
10 36 10	5 0	10 49 30	7 30
10 37 48	4 45	11 0 46	12 40
10 39 14	5 0	11 2 5	13 5
10 46 25	7 0	11 3 10	14 0
10 47 35	7 15	11 8 17	16 15

The foregoing measures were taken by myself with an 8-inch sextant at the Greenwich Hospital School Observatory. They are given as read off from the instrument, without the omission of a single observation, and require 34″ to be taken from each for index-error, which was determined with great care before and after the observations.

The times were observed with a chronometer going sidereal time, and require each to be increased by 18^s, the quantity

which the chronometer was slow of sidereal time, as determined by comparisons with the transit-clock before and after observations, both comparisons agreeing.

Although the weather was occasionally cloudy, yet the measures were taken under favourable circumstances, and accord with each other as nearly as can be expected in single sextant observations.

The commencement and end of the eclipse were also observed under favourable circumstances with a 40-inch equatoreal of 3-inch object-glass, power 45, as follows:—

	Sid. Time. h m s	M. S. Time. h m s
Commencement	9 26 3	1 39 43
End	11 40 37	8 53 54

As a very slight impression upon the sun's limb was made when the time of the commencement was recorded, perhaps about 1 or at most 2 seconds of time might be subtracted from the time here given, making the mean sidereal time of commencement $1^h\ 39^m\ 41^s$, instead of $1^h\ 39^m\ 43^s$.

Latitude 51° 28′ 50″ N.; Longitude $0^{s}\cdot2$ W.

Greenwich Hospital Schools, July 19, 1860.

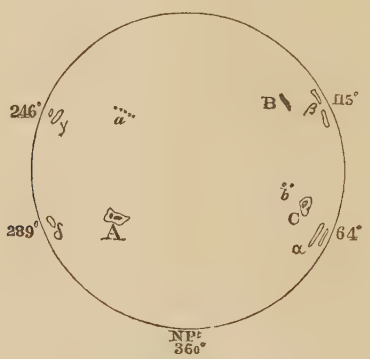
Observed at Maresfield, Sussex, by Captain Noble.

For some two hours prior to the moment of first contact I was occupied in the delineation of the map of the sun, which accompanies this paper, and which represents that luminary at a mean epoch of July 18th, 1^h G.M.T. Reference to the key to the larger drawing will show that I have lettered the three large maculæ in the order of their right ascension, A, B, and C; the minute groups I have called *a* and *b*; and the four most noticeable faculæ are designated α, β, γ, and δ. The chief spot (A) consisted of several umbræ contained in, or surrounded by, one penumbra; and it will be seen that prolongations of this penumbra extended to some, otherwise isolated, minute spots, at some little distance from the main mass. Spot B was of a long oval form, and a curious (dark) break was perceptible, dividing the umbra into two portions; and spot C consisted of two separate ones, surrounded by a single penumbra. The two small groups, *a* and *b*, scarcely demand any notice. With reference to the faculæ, that marked α in the key-map was situated at an angle of about 64° from the true north point, measuring (as in the ordinary position-micrometer) towards the east. It was double, and consisted of two nearly parallel fusiform streaks of light; the smaller, or following, one of which inclined at its higher, or southern part, towards the larger. β was a very confused group of faculæ (with maculæ intermixed) just being brought on to the sun's disk by his rotation; it was at

a position-angle of about 115°. Proceeding onwards, we arrive at γ, another double facula, with a distant resemblance to α. In this case the preceding streak inclined towards the other in a sharp curve; they were about 246° from the north point. Finally, δ, at an angle of 289°, reminded me forcibly of a "Prince Rupert's drop" in its form: it was quite isolated. I may add that I took great pains with the drawing and mapping of the various physical details on account of their possible connexion (that of the faculæ especially) with the "red flames," and trust that the result may be comparable with the observations of those in Spain who witnessed these remarkable appearances, and determined their apparent position on the solar limb.

The Eclipse.—The moment of first contact was, I believe, at $9^h\ 26^m\ 55^s$ L.S.T. = $1^h\ 40^m\ 45^s$ L.M.T. The moon's advancing limb was exceedingly rugged, four high mountains being very conspicuous. It is a curious fact that the moon appeared to have the effect of stilling the undulations of the solar limb at the points where she cut it. At $9^h\ 43^m\ 23^s$ L.S.T. = $1^h\ 57^m\ 0^s{\cdot}3$ L.M.T. the moon's limb centrally covered the group lettered A, and soon afterwards the advance of our satellite disclosed a regular sierra of mountains to the south of those already seen. At $2^h\ 6^m$ L.M.T. I turned the telescope on *Venus*, who was then about 11 hours from her inferior conjunction. She presented an exquisitely beautiful appearance, and her brilliancy was considerably heightened by the relative darkness which prevailed. I send a drawing of the appearance which she exhibited: albeit it is difficult to convey her extreme apparent tenuity faithfully. To return to the sun:—At $10^h\ 24^m\ 18^s$ L.S.T. = $2^h\ 37^m\ 48^s{\cdot}6$ L.M.T. the moon's limb was centrally over spot B, whence it steadily advanced and covered spot C centrally at $10^h\ 32^m\ 33^s$ L.S.T. = $2^h\ 46^m\ 2^s{\cdot}2$ L.M.T.; not the slightest change was remarked in the aspect of the maculæ, as the moon approached them, both umbræ and penumbræ remaining perfectly sharp and crisp up to the lunar limb. For some time after this the effect of the sunlight, as seen with the naked eye, was very remarkable. A dimness and dullness of a lurid tint seemed to overspread the landscape. Something of the sort might have been produced by a dense veil of mist covering the sun, but the continuation of sunshine and the sharpness of the shadows thrown by posts, rails, and trees, at once must have shown, even to a person ignorant of the eclipse, that this curious diminution of light had no reference to any merely atmospheric cause. The effect of comparative darkness was considerably more striking than on the occasion of the larger eclipse of March 15th, 1858; as, on that day, the dense, impenetrable nimbi only conspired with the obscured sun to give the effect of a dull summer evening; whereas, on the present occasion, this odd unearthly light was coexistent with apparently full sunshine. I may add that a curious and instructive effect of irradiation was presented at

this time, when any temporary passing cloud enabled the observer to regard the sun with the naked eye, or with a pale tinted glass. Under such circumstances, the moon's limb appeared to cut off scarcely one-third of the solar disk; and it was only on reference to the telescope, or on the employment of a glass sufficiently darkened, that the illusion was dispelled, and it was seen that in reality the sun was more than two-thirds obscured. At $10^h\ 4^m\ 8^s{\cdot}3$ L.S.T. $= 3^h\ 1^m\ 29^s{\cdot}7$ L.M.T. spot A was again centrally uncovered; and at $11^h\ 15^m\ 11^s$ L.S.T. $= 3^h\ 28^m\ 33^s{\cdot}2$ L.M.T. the lunar limb was just half off spot C. After this, the clouds which had more or less been scattered over the heavens all day, began to close rapidly over the sun, and, consequently, the emergence of spot B, and the moment of last contact of the limbs of the sun and moon, were invisible. I made a despairing effort to observe the last contact with the whole telescopic aperture, and an eye-piece undefended even by a dark glass, but in vain, the clouds were impenetrable! I observed, as usual, with my Ross equatoreal of 4·2 inches aperture. The map was made with an eye-piece magnifying 115 times and wired in squares of 1′ each. The eclipse was viewed with a power of 74, and throughout the whole aperture of the telescope was employed, and a piece of smoked talc placed within the focus of the object-glass; an arrangement which I find affords an exquisite view of the details of the solar disk, and which obviates the necessity for diminishing the area of the object-glass by diaphragms.



Key to Map of the Sun, July 18, 1860.
(at 1 hour G.M.T.)

A, large Spot (or group in one penumbra) preceding. B and C smaller spots following. *a*, minute group of spots nearly S of A. *b*, minute group of spots S P C. *α*, double facula at a position angle of 64°. *β*, group of faculæ (with maculæ intermixed, just coming on to the sun's disk) at an angle of 115°. *γ*, another double facula at 246°. *δ* a facula in the form of a "Prince Rupert's drop," at an angle of 289°. The angles are measured from the north point round by the E, S & W, as in the common position micrometer, and are subject to a probable error of ±1°.

Observed at Uckfield, Sussex, by C. Leeson Prince, Esq.

On the morning of July 18th, 1860, the sky was densely overcast, and some heavy showers fell at intervals before 9 A.M. At 10 A.M. the sky still remained obscured, and it was not until about $10^h\ 40^m$ that a patch of blue sky becoming visible over the Downs, gave some hope that a glimpse of the eclipse might, perhaps, be obtained. At $11^h\ 30^m$ the sky was about half covered by cloud. At noon the whole of the southern sky was almost free from cloud, and, with the exception of an occasional broken cumulus passing before the sun, the sky remained clear till a little past 3 P.M.

The major portion of the phenomenon was seen to great advantage in this latitude. The atmosphere was found to be remarkably diaphanous, and not the slightest tremor could be observed upon the edge of the solar disk. The faculæ and spots were seen beautifully defined.

As a prelude to any notes of the time of contact, I will remark that my observatory is situated 200 feet above the level of the sea, in latitude 50° 58′ 25″ North, and in longitude $0^h\ 0^m\ 24^s{\cdot}3$ East. My equatoreal telescope has an aperture of 6·8 inches, and a focal length of 12 feet.

By applying a Dawes eye-piece to a power of 140, I was enabled to use very satisfactorily the whole aperture of the object-glass. The first contact happened exactly at $9^h\ 27^m\ 6^s$ local sidereal time; and I almost immediately observed two remarkable lunar peaks enter upon the sun's disk, and as nearly as possible at the point of contact.

The following notes of time I took with great care:—

	Large Spot. Local Sid. Time. h m s	Spot West of two. Local Sid. Time. h m s	Spot East of two. Local Sid. Time. h m s
First contact with Penumbra	9 41 47	10 23 53	10 31 52
,, with Spot	9 43 3	10 24 14	10 32 14
Spot occulted	9 43 46	10 24 40	10 33 4
Penumbra occulted	9 44 31	10 24 54	10 33 19

At the time of greatest obscuration the horns of the crescent were particularly sharp and well defined, without the least sign of distortion which could be attributed to a supposed lunar atmosphere. The diminution of light was very considerable, and objects at a short distance appeared enveloped in a grayish blue haze, somewhat similar to the peculiar hue cast upon the landscape on a hot summer day, just after the sun has been obscured by a dense mass of cumulo-stratus cloud threatening a hasty shower. Soon after 3 P.M. clouds gradually came up from the south-west, and from $3^h\ 30^m$ the sun was entirely obscured during the remainder of the eclipse. I imagined that the last contact could not have been seen in this county.

Uckfield, Sussex, Oct. 20, 1860.

Observed at Highbury, by T. W. Burr, Esq.

Being unable to leave England at the time of the Eclipse, I made such observations of the attendant phenomena as the weather permitted. The morning was exceedingly unfavourable, but about noon considerable improvement took place, the sun being visible, though the sky still remained cloudy. From one o'clock to half-past it was very fine, but as the time for the commencement of the eclipse approached the clouds closed and the first contact was lost, the sun not being seen again till $1^h 49^m 31^s$, G.M.T., when the moon had made some progress on its disk. I had intended making a careful diagram from measures of the sun's appearance before the eclipse, upon which its successive phases could have been indicated; but there was no opportunity for doing this work. There were three conspicuous spots, or rather clusters, on the sun's face; one, the largest and most complex, near the south-east limb (as seen in the inverting telescope), and the other two near the north-west and west parts of the disk. Having failed to catch the first impression of the moon's limb on the sun, the next thing was to obtain as many time-observations of the passage over the spots as possible; and the contact of the moon with the penumbra of the first and largest cluster of spots took place at $1^h 54^m 10^s{\cdot}6$ G.M.T. At $1^h 55^m 30^s{\cdot}3$ the largest nucleus of this mass was reached, and by $1^h 56^m 20^s$ the whole of the nuclei in this cluster were covered. The disk being now clear for a considerable space, attention was directed to the appearance of the moon's limb, which was distinctly seen to be very rough and serrated; while both it and the sun's edge were in a state of great undulation, and it was perfectly obvious that had the two disks been concentric, the uneven edge of the moon, with its prominences and depressions exaggerated by the "boiling" and irradiation, would almost certainly have produced the effect of rendering "Baily's beads" visible at the two points of contact. I was also particularly struck at this time ($2^h 25^m$) by seeing a portion of the moon visible beyond the part where it was projected on the sun. This was evident at both places where it cut the disk, but more particularly at the upper cusp. The moon's body was visible for about 4′ from the sun's border, and was seen, not by any light proceeding from it, but by its intense blackness as compared with the sky background. The impression on the eye was not a transient one, but was seen, whenever the eclipse was visible, for half an hour from this time. At $2^h 35^m 51^s{\cdot}5$ the penumbra of the second spot was reached, and by $2^h 36^m 43^s$ the spot and penumbra were covered. Dense clouds then covered the heavens until after the greatest obscuration, and nothing could be noted but the terrestrial appearances. These were sufficiently striking:—a gradual gloom had come over the scenery, the clouds having a lurid character similar to an impending thun-

derstorm ; they were very dark, and seemed lower than usual ; in fact, they gave the impression of a rapid descent on the earth. The wind blew strongly from the south-west, and produced an unpleasant and unusual chilliness. Near the zenith a few breaks showed the sky of a deep indigo hue, while towards the horizon, which was very indistinct, the clouds had a copper-coloured tinge. Birds appeared to be returning to the trees from their excursions, and were noticeably silent during the greatest gloom. By $3^h\ 5^m$ most of these peculiar effects were gone ; the clouds had become light and silvery, the sky between them pale blue, and the wind lowered. The passage of the obscurity from the north-west to the south-east could also be distinctly traced. The temperature now began to rise from the depression it had suffered. During the brightest part of the morning, about $1^h\ 30^m$, the thermometer had reached $71^\circ{\cdot}5$; it fell gradually during the eclipse to $2^h\ 50^m$, when it stood at $61^\circ{\cdot}5$, and afterwards recovered the elevation of 65° by four o'clock, when the eclipse was over. The passage of the moon again became visible, and at $2^h\ 58^m\ 29^s{\cdot}9$ a very small spot, below the large one, was uncovered. In another minute the nucleus of the large spot began to emerge, and by $3^h\ 0^m\ 19^s$ was quite clear. At $3^h\ 0^m\ 54^s{\cdot}4$ the penumbra of this cluster was entirely visible. Clouds again intervened, and when they had passed, the second spot was clear ; and at $3^h\ 42^m\ 52^s{\cdot}5$ the nucleus of the third spot appeared. I was very desirous of getting an observation of the time of the last contact, but the clouds deprived me of it. I saw the moon still projected on the sun at $3^h\ 52^m\ 38^s{\cdot}9$, and evidently within a few seconds of leaving it ; but a cloud once more covered them, and when the sun reappeared at $3^h\ 54^m\ 25^s$, the eclipse had passed. My observations were made throughout with my usual instrument, the equatoreal by Ross, of $3\frac{3}{8}$ inches aperture, at first with direct vision and a power of 58 ; but after the largest spot was passed, a Hodgson reflector was used, with a power of 100. The latitude and longitude of my observatory are $51^\circ\ 33'\ 42''{\cdot}1$ N. and $23^s{\cdot}9$ W.

August 1860.

Observed at Haddenham, Bucks, by the Rev. W. R. Dawes.

The solar eclipse of July 18 was observed here under remarkably favourable circumstances until the greatest obscuration was past, when the thin and detached clouds, which had prevailed during the earlier part of the afternoon, thickened so much as completely to obscure the termination of the eclipse.

The first impression on the sun's edge was made by the highest part, near the southern extremity, of the remarkable chain of hills on the moon's eastern limb, named " The D'Alembert Mountains " in the Rev. T. W. Webb's excellent index

map, in his very useful little work entitled *Celestial Objects for Common Telescopes*. During nearly the whole time that the eclipse was visible the image was unusually tranquil, and so distinct, even through the thin stratum of cloud which often covered it, that on my $8\frac{1}{4}$-inch object-glass powers of from 145 to about 520 were employed with excellent effect. The most minute and delicate feathery portions of the penumbra of the large spot in the sun's north-western quadrant were thus brought out with admirable distinctness, and their occultation by the moon's sharply defined edge was most carefully watched. Neither on these, nor on the darker part, (or *umbra*,) of the spot, was the slightest effect produced, either in form or shade, previous to their disappearance.

The moon's limb, just off the disk of the sun and close to it, was repeatedly examined by placing portions of it in a small field of my solar eye-piece, from which the sun was excluded, and using as light a shade as my eye could comfortably bear. No light on any part of the moon's edge could be even suspected.

About the time of the greatest obscuration a very thin cloud near the sun to the south displayed extraordinarily vivid prismatic colours, through a part of which the planet *Venus*, then very nearly at her inferior conjunction, appeared of a delicate pink. This planet was visible through the cloud when the aperture of the finder was reduced to half an inch; and in a clear sky, with an aperture of only $0^{in}\cdot36$, she looked like a semicircular nebula. Her distance from the sun's southern limb was about 5°.

Haddenham, Thame, Nov. 1860.

Communications were also received from—

Mr. F. Morton, at the Wrottesley Observatory. On account of the unfavourable state of the weather the first contact could not be seen, but the last contact was observed to take place at $3^h\ 41^m\ 56^s$, Wrottesley mean time; but as it was seen through the edge of a cloud the time is considered as uncertain to the extent of about one second.

John M. Stodhart, at Dublin; the morning was so cloudy that all idea of telescopic observations was abandoned, and the only observations obtained were of the barometer and thermometer.

C. B. Chalmers, Shanty Bay, County of Simcoe, Canada West. The first and last contacts are stated to have been well observed, and the occultations and emergencies of several spots were also observed, but the times were obtained to minutes only.

The Society has been favoured with a communication from Thomas Frazer, Esq., Secretary of the Hudson's Bay Company, enclosing Reports of Observations of the Eclipse, made by several of the officers of the Company, J. Mackenzie, at Moose Factory, Chief Trader R. Hamilton, at Great Whale River; Chief Trader J. R. Clare, at York Factory; J. P. Gardiner, at Churchill; and Will. Simpson, at Fort Churchill. But the want of instruments and the general unfavourable state of the weather were impediments in the way of any precise observations.

Papers were also received from the Astronomer Royal for Scotland and from Mr. Carrington, containing the determination of the positions of the principal spots near the circumference of the sun's disk, as well on the visible as the invisible hemisphere, at the time of the eclipse.

Results of Meridional Observations of Small Planets and Occultations of Stars by the Moon, observed at the Royal Observatory, Greenwich, from June to October 1860.

(*Communicated by the Astronomer Royal.*)

Metis ⑨.

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 16	12 5 4·0	21 47 26·76	.....
22	11 35 32·4	21 41 29·68	113 34 7·38
27	11 11 5·0	21 36 41·06	113 55 17·52
31	10 51 43·8	21 33 2·84	114 8 51·50
Sept. 1	10 46 55·3	21 32 10·14	114 11 50·14
11	10 0 2·0	21 24 34·66	114 30 29·09
12	9 55 28·8	21 23 57·23	114 31 10·21
19	9 24 21·4	21 20 20·66	114 31 1·77
Oct. 2	8 30 31·8	21 17 37·32	114 7 49·83
4	8 22 42·9	21 17 40·29	114 1 53·55
8	8 7 27·2	21 18 8·25	113 48 10·93
11	7 56 19·1	21 18 48·07	113 36 26·52
17	7 34 50·3	21 20 55·03	113 9 22·71
20	7 24 28·2	21 22 20·85	112 54 15·85
26	7 4 26·3	21 25 55·04	112 20 46·75
29	6 54 45·2	21 28 2·00	112 2 40·64
30	6 51 34·1	21 28 46·89	111 56 27·49

Flora (8).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	° ′ ″
1860, Oct. 20	13 57 19·9	3 56 17·11	80 35 22·96

Irene (14).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 16	11 38 2·9	21 20 21·22	117 0 41·79
17	11 33 12·6	21 19 26·74	117 5 16·03
22	11 9 8·1	21 15 1·06	117 26 1·34
Sept. 6	9 59 8·8	21 3 58·53	118 2 30·63
12	9 32 27·4	21 0 52·08	118 6 24·64
Oct. 4	8 2 33·7	20 57 27·78	117 35 29·23

Eunomia (15).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 16	12 8 54·7	21 51 18·13	90 50 56·07
17	12 4 0·0	21 50 19·11	90 50 5·29
22	11 39 24·4	21 45 22·31	90 47 38·64
27	11 14 53·7	21 40 30·36	90 48 16·78
29	11 5 10·9	21 38 39·04	90 49 18·67
30	11 0 17·6	21 37 41·54	90 49 59·32
31	10 55 27·2	21 36 46·83	90 50 44·17
Sept. 1	10 50 37·4	21 35 52·84	90 51 39·29
10	10 7 58·7	21 28 36·09	91 2 16·21
11	10 3 20·9	21 27 54·10	91 3 39·61
12	9 58 44·7	21 27 13·68	91 5 10·89
13	9 54 10·0	21 26 34·75	91 6 38·71
14	9 49 36·7	21 25 57·30	91 8 13·04
19	9 27 16·2	21 23 15·91	91 15 55·59
Oct. 2	8 32 45·2	21 19 51·16	91 33 13·28
3	8 28 46·9	21 19 48·76	91 34 11·67
5	8 20 55·9	21 19 49·55	91 35 57·52
8	8 9 23·5	21 20 4·93	91 38 4·51
9	8 5 36·7	21 20 14·04	91 38 40·29
11	7 58 8·3	21 20 37·52	91 39 26·95
20	7 26 0·4	21 23 53·32	91 38 33·54
22	7 19 8·3	21 24 53·20	91 37 10·11
26	7 5 52·4	21 27 21·37	91 33 8·50

Fortuna (19).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	° ′ ″
1860, Oct. 20	13 12 55·2	3 11 45·12	72 34 8·34

Calliope (22).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, June 14	10 54 46·3	16 28 34·41	114 24 47·10

Euterpe (27).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Oct. 3	12 8 43·6	1 0 21·55	86 41 44·15
16	11 5 22·6	0 48 5·37	87 55 51·12
17	11 0 32·4	0 47 10·88	88 1 3·44
18	10 55 42·6	0 46 16·87	88 6 10·62
20	10 46 5·6	0 44 31·43	88 15 58·44

Bellona (28).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 17	9 48 13·3	19 34 10·12	106 39 34·93
Sept. 19	7 32 24·2	19 28 5·04	108 32 7·55

Amphitrite (29).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Oct. 20	13 29 22·7	3 28 15·30	63 22 28·19
29	12 46 17·7	3 20 32·28	63 17 7·05

Harmonia (40).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, July 20	10 20 5·4	18 15 43·94	114 50 3·39

Isis (42).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, July 6	11 52 16·5	18 52 58·39	118 45 57·04
14	11 13 17·1	18 45 25·04	119 47 29·36
Aug. 17	8 45 56·4	18 31 42·99	122 11 48·26

Europa (52).

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Aug. 4	11 8 19·3	20 3 14·11	109 8 24·99

Planet (59).

Mean Solar Time of Observation.		Apparent R.A.	Apparent N.P.D.
	h m s	h m s	° ′ ″
1860, Sept. 18	12 43 16·8	0 35 52·15	89 44 35·45
19	12 38 41·2	0 35 12·32	89 53 44·98
25	12 10 54·9	0 31 0·78	90 49 15·43
Oct. 3	11 33 41·1	0 25 13·32	92 2 4·09
16	11 33 58·2	0 16 35·80	93 46 0·28
17	10 29 28·3	0 16 1·69	93 52 50·96

All the observations of N.P.D. have been corrected for parallax.

Occultations of Stars by the Moon.

Day of Obs.	Phenomenon.	Moon's Limb.	Mean Solar Time.	Observer.
			h m s	
1860, Sept. 6	27 Tauri, disapp.	Bright	12 32 19·6	C.
6	27 Tauri, disapp.	Bright	12 32 12·8 (*a*)	J. C.
6	28 Tauri, disapp.	Bright	12 34 40·0	E.
6	η Tauri, reapp.	Dark	12 49 41·0	E.
6	η Tauri, reapp.	Dark	12 49 40·4	J. C.
6	27 Tauri, reapp.	Dark	13 37 24·3	E.
6	27 Tauri, reapp.	Dark	13 37 25·5	J. C.
6	28 Tauri, reapp.	Dark	13 43 40·7	E.
6	28 Tauri, reapp.	Dark	13 43 40·2	J. C.

(*a*), Uncertain to about half a second.

The initials E. and J. C. are those of Mr. Ellis and Mr. Carpenter.

Elements of Planet (59), *determined from the meridian observations made with the Transit Circle at the Royal Observatory, Greenwich, on Sept.* 18, *Oct.* 3, *and Oct.* 16. By Mr. W. Ellis, Assistant at the Royal Observatory, Greenwich.

Mean Anomaly	350° 56′ 49″·2	1860, Oct. 2, 12^h G.M.S.T.
Long. of Perih.	18 55 46·7	Mean Equinox 1860·0
,, Asc. Node	170 18 17·0	Mean Equinox 1860·0
Inclination	8 36 30·5	
ϕ	6 49 30·6	
Log a	0·4336174	
μ	793″·561	

Approximate Ephemeris, calculated from the Elements above.

For Greenwich Mean Noon.

1860.	Apparent R.A.	Apparent N.P.D.	Log. Δ
	h m s	° ′	
Nov. 5	0 9 18	95 20·2	0·1973
6	9 10	95 22·6	
7	9 4	95 24·8	
8	9 0	95 26·8	
9	8 57	95 28·5	0·2072
10	8 56	95 30·0	
11	8 56	95 31·2	
12	8 58	95 32·2	
13	9 2	95 33·0	0·2175
14	9 7	95 33·6	
15	9 14	95 34·0	
16	9 22	95 34·1	
17	9 32	95 34·0	0·2281
18	9 43	95 33·6	
19	9 56	95 33·1	
20	10 11	95 32·4	
21	10 27	95 31·4	0·2390
22	10 44	95 30·2	
23	11 3	95 28·9	
24	11 24	95 27·3	
25	11 46	95 25·5	0·2501
26	12 9	95 23·5	
27	12 34	95 21·4	
28	13 1	95 19·1	
29	13 28	95 16·5	0·2613
30	13 58	95 13·8	
Dec. 1	14 28	95 10·9	
2	15 0	95 7·8	
3	15 33	95 4·5	0·2724
4	16 7	95 1·1	
5	16 43	94 57·5	
6	17 20	94 53·8	
7	17 59	94 49·8	0·2835
8	18 38	94 45·7	
9	19 19	94 41·4	
10	20 1	94 37·0	
11	20 45	94 32·6	0·2945
12	21 29	94 27·9	
13	22 15	94 23·0	
14	23 2	94 18·0	

1860.	Apparent R.A. h m s	Apparent N.P.D. ° ′	Log. Δ
Dec. 15	23 50	94 12·9	0·3055
16	24 39	94 7·6	
17	25 29	94 2·2	
18	26 21	93 56·7	
19	27 13	93 51·0	0·3162
20	28 7	93 45·3	
21	29 1	93 39·4	
22	29 57	93 33·4	
23	30 53	93 27·2	0·3269
24	31 51	93 20·9	
25	32 49	93 14·5	
26	33 49	93 8·0	
27	34 49	93 1·5	0·3372
28	35 50	92 54·9	
29	36 53	92 48·1	
30	37 56	92 41·2	
31	0 38 59	92 34·2	0·3474

Nov. 7.

Remarkable Changes observed in the Cluster 80 *Messier.* By Norman Pogson, Esq., Director of the Hartwell Observatory.

(*Communicated by Dr. Lee.*)

This fine globular object, although described as "a compressed cluster," had, until this year, always presented the appearance of a well-defined nebula to my eye, under the moderate powers with which I have been accustomed to behold it. As it comes in the same field of view with M. Chacornac's pair of variable stars, R and S *Scorpii*, it has been under regular inspection for the last seven years; from 1853 to 1856 by the French astronomer, and since 1857 by me also. Admiral Smyth examined it in 1837 and again in 1839, but he, as also Messier, Sir John Herschel, Professors Argelander and D'Arrest, recorded it as either "cometary" or "nebulous."

On the 28th of last May, when searching after the two above-named variable stars, neither of which was then visible, my attention was arrested by the startling appearance of a star of the 7.6 magnitude in the place which the nebula had previously occupied. The power used was 118, on the Hartwell equatoreal; and so recently as May 9th—the last night on which R *Scorpii* was visible—I am able to state positively that the nebula was as usual, and had nothing stellar about it,

with the self-same power and instrument. On June 10th, with power 66, the stellar appearance had nearly vanished, but the cluster yet shone with unusual brilliancy and a marked central condensation. I mentioned this extraordinary phenomenon to Mr. Hind on May 30th, also to Admiral Smyth and Dr. Lee, but pressing and anxious business so distracted my attention about that time that I neglected to announce it *publicly*, and had almost forgotten the occurrence until the arrival of the *Astronomische Nachrichten*, No. 1267, in which Prof. E. Luther of Königsberg corroborated my records, by stating that he and M. Auvers had perceived the change on May 21st, a week earlier than my first note, but only twelve days after it had been seen unchanged and nebulous. On the evening of the 21st Prof. Luther estimated it 6.5 magnitude, M. Auvers 7, (mean 6.8); the following night it appeared about the same, but on the 25th somewhat smaller. My own observation of it, when of the 7.6 magnitude, joins well in with those of the Königsberg astronomers; as also does its disappearance on June 10th.

It is, therefore, incontestably proved, upon the evidence of three witnesses, that, between May 9th and June 10th of this year, the cluster known as 80 *Messier* changed, *apparently*, from a pale cometary looking object, to a well-defined star, fully of the seventh magnitude, and then returned to its usual and original appearance. It seems to me absurd to attribute this phenomenon to actual change in the cluster itself, but it is very singular if a new variable star, the third in the same field of view, should be situated exactly between us and the centre of the cluster. Should such be the true explanation, the mid-way variable star must be similar in nature but of greater range than Mr. Hind's wonderful U *Geminorum*. The cluster should be closely watched in some Southern observatory.

Hartwell Observatory, Oct. 8, 1860.

Magnitude Constants for Fifty-seven of the Minor Planets. By Norman Pogson, Esq., Director of the Hartwell Observatory.

(*Communicated by Dr. Lee.*)

A list of the apparent magnitudes of the minor planets, at the commencement of each month throughout the year, was first supplied for 1857, and has since been given annually. In the third year of its existence it was adopted by the Superintendent of the *Nautical Almanac*, as a suitable addition to the Supplement of that work, and it has since continued to appear therein. The scale of estimation employed is based upon the light ratio 2·512; and the photometric range belong-

ing to any good average telescope is sufficiently defined by the formula:—

Limit of Vision = 9·2 mag. + 5 times log. aperture in inches.

The magnitude of any planet, whose mean distance from the sun is denoted by a, and its actual distances from the sun and earth, as usual, by r and Δ, becomes known by the expression:

$$\text{Magnitude} = M - 5 \log (a^2 - a) + 5 (\log r + \log \Delta)$$

or putting N for the first two terms:—

$$\text{Magnitude} = N + 5 (\log r + \log \Delta)$$

The constant M is the mean opposition magnitude; *i.e.* the brilliancy of any planet, if, when in opposition, it and the earth were at their respective mean distances from the sun. The number N is the magnitude such planet would acquire, supposing it, the sun and the earth, to be situated at the three angles of an equilateral triangle, the sides of which equal the earth's mean distance from the sun. The number of estimations upon which these light constants depend is added, and although at least twenty of each will be obtained before *final* values are adopted, there is seldom much risk of great error after four or five nights' careful records have been secured.

The utility of the magnitude ephemeris itself, as a means of saving time and trouble to planetary observers, cannot be too plainly illustrated, and I therefore beg leave to offer two very familiar examples to the notice of the Society. Agreeably to my own experience, I consider that a star or planet, to be satisfactorily observable with a ring or other dark field micrometer, must be at least three-fourths of a magnitude brighter than the limit of vision of the telescope; but that with spider lines, and the smallest amount of requisite illumination, it will be *impossible*, under ordinary conditions, to observe an object less than two entire magnitudes within or brighter than the limit. Thus, on the photometric scale adopted, 12·2 magnitude being the limit of vision for a four-inch aperture, the faintest planet observable with illumination will be a trifle below the tenth magnitude; or, with a ring-micrometer and dark field, will be of the 11.5 magnitude. For the great transit circle of the Royal Observatory, eight inches in aperture, the limit of vision being 13.7 magnitude, planets under the 11.5 magnitude cannot well be observed with illumination; though disappearances behind thick bars might, with difficulty, be noted almost to the thirteenth magnitude.

When the predicted magnitude of a faint planet is brighter than its mean opposition magnitude, it should be well followed up. Thus; *Euphrosyne*, *Atalanta*, *Hestia*, and *Virginia*, may be easily recognised at their next oppositions; while *Polyhymnia*

and *Circe* may be despaired of, except with monster equatoreals and dark field micrometers.

The ephemeris for 1861, based upon the following constants, will be found upon pages 71 and 72 of the Supplement to the *Nautical Almanac* for the year 1864, just issued by Mr. Hind.

Planet.	M.	N.	Obs.
(1) Ceres	7·7	4·3	14
(2) Pallas	8·0	4·5	16
(3) Juno	8·5	5·3	3
(4) Vesta	6·6	4·1	10
(5) Astrea	10·0	6·9	19
(6) Hebe	8·6	5·9	24
(7) Iris	8·6	6·0	33
(8) Flora	8·9	6·8	22
(9) Metis	8·9	6·3	15
(10) Hygeia	9·8	5·6	13
(11) Parthenope	9·5	6·7	20
(12) Victoria	9·6	7·2	12
(13) Egeria	9·9	6·8	12
(14) Irene	9·7	6·6	15
(15) Eunomia	9·1	5·9	17
(16) Psyche	10·1	6·3	12
(17) Thetis	10·0	7·2	10
(18) Melpomene	9·5	7·1	18
(19) Fortuna	9·7	6·9	16
(20) Massilia	9·3	6·6	14
(21) Lutetia	10·5	7·7	13
(22) Calliope	10·0	6·3	9
(23) Thalia	10·5	7·4	10
(24) Themis	11·0	6·8	5
(25) Phocea	10·6	8·0	5
(26) Proserpine	10·7	7·5	12
(27) Euterpe	9·7	7·2	8
(28) Bellona	10·1	6·7	6
(29) Amphitrite	9·1	6·1	34
(30) Urania	10·0	7·5	14

Planet.	M.	N.	Obs.
(31) Euphrosyne	11·6	7·4	4
(32) Pomona	10·7	7·6	7
(33) Polyhymnia	11·6	8·0	12
(34) Circe	11·7	8·5	6
(35) Leucothea	12·2	8·3	11
(36) Atalanta	12·9	9·5	5
(37) Fides	10·5	7·4	11
(38) Leda	11·1	7·8	9
(39) Letitia	9·4	6·0	6
(40) Harmonia	9·1	6·8	14
(41) Daphne	10·2	7·6	1
(42) Isis	10·5	7·8	18
(43) Ariadne	10·2	8·1	12
(44) Nysa	10·3	7·6	7
(45) Eugenia	10·8	7·5	7
(46) Hestia	11·6	8·6	9
(47) Aglaia	11·2	7·5	9
(48) Doris	11·0	6·9	7
(49) Pales	10·8	6·8	13
(50) Virginia	11·9	8·7	5
(51) Nemausa	10·4	7·9	6
(52) Europa	10·5	6·4	19
(53) Calypso	11·5	8·4	3
(54) Alexandra	11·0	7·7	5
(55) Pandora	10·9	7·5	13
(56) Pseu. Daph.	11·5	8·4	1
(57) Mnemosyne	10·9	6·8	7

Hartwell Observatory, Nov. 8, 1860.

On a Photograph of the Sun, taken with the Northumberland Telescope of the Cambridge Observatory. By Professor Challis.

In making the following photographic experiment I was favoured, through the kindness of a friend, with the valuable assistance of Mr. Hardwick, to whose skilful preparation of the collodion sensitized plates, and processes of development, the success of the experiment is mainly to be attributed. For the support of the photographic apparatus a frame, made for lightness of deal and covered with blackened canvass, was prepared, so that it could be readily and firmly attached to the eye-end of the telescope. The form of the frame was in part cylindrical, and in part that of a frustum of a four-sided pyramid, the smaller end of which was provided with grooves for holding the plates. The proper position of the eye-piece was ascertained by adjusting it so as to cast an image of the sun on a sheet of paper put in the place prepared for the sensitized plate; but no attempt was made to allow for the difference of the focal lengths of the telescope for the chemical and luminous rays, which in this mode of experimenting appears to have little effect. The remaining operations were extemporised after Mr. Hardwick's arrival at the observatory on July 28, on which day from 2^h to to 3^h the experiments were made. In the first instance the whole aperture of the object-glass, the diameter of which is $11\frac{3}{4}$ inches, was tried; but the sun's action being found to be far too strong the aperture was greatly reduced, till the diameter finally fixed upon was not more than $1\frac{1}{4}$ in. As no means had been provided for admitting and stopping the sun's rays at the eye-end of the telescope, without causing an injurious amount of tremor, an opaque screen was mounted on a pole and held at a small distance from the object-glass, and on a signal being given, when the plate was in place, the screen was passed and returned so as to expose the aperture to the solar rays as brief an interval as was possible with this mode of operating. It would have been better to have simply moved a slit in the screen across the aperture; for, although the aperture was so much reduced, the sun's action was still too strong.

The focal length of the Northumberland telescope being $19\frac{1}{2}$ ft., the diameter of the image of the sun's disk formed at the focus on the day of the experiment was 2·15 in. The magnifying power of the eye-piece was 100, and the distance of the photographic plate from the focus of the object-glass about 13 inches. By the reduction of the effective aperture the brightness of the focal image was diminished in the ratio of the square of $11\frac{3}{4}$ to the square of $1\frac{1}{4}$, that is, in the ratio of 78 to 1. And as the diameter of the image thrown on the plate was found by measurement to be 11·42 in., the ratio of the brightness of this image to that of the focal image was equal to the square of the ratio of 2·15 to 11·42, that is, to the ratio of 1 to 28

nearly. Although the brightness of the final image was thus made less than that of the focal image formed by the whole aperture of the object-glass, in the ratio of 1 to 2200 nearly, the sun's action during a very small fraction of a second sufficed to produce a very decided impression.

The photographic picture resulting from the experiment (a specimen of which accompanies this note) exhibits a portion of the sun's disk, limited by the boundary of the field of view and by an arc of 43° of the limb, and containing two groups of spots of moderate size. The contrast between the dark nucleus and its surrounding penumbra, and the definite exterior boundary of the latter, are well expressed. About the group which is nearest the limb, the *faculæ* which generally accompany groups in this position are distinctly visible. Also the diminution of the brightness of the sun's disk towards the periphery, which is now an admitted fact, is very manifest in the photograph.

During the experiment the equatoreal was carried by clock-movement. When, however, the time of exposure is as brief as it was in this instance, this movement, which necessarily produces some amount of tremor, may probably with advantage be dispensed with. If at the same time the sun's rays be admitted at the object-glass in the manner above described, instrumental tremor will be completely avoided. The method of admitting the light by suddenly letting fall a diaphragm connected with the telescope is faulty in principle, because the breaking of the connexion is mechanically equivalent to giving an impulse to the telescope. Also if the diaphragm be let fall at the eye-end of the telescope, the light which passes through the slit must, as it crosses the field, be accompanied with diffraction light; whereas if the light be admitted at the object-glass, there is no diffraction light except at the boundary of the field, where it is of no consequence. It is known, from the principles of optics, that in the latter arrangement the *whole* of the image within the field of view is illumined, so long as the sun's rays are not entirely cut off by the diaphragm, and consequently that the illumination advances gradually from zero to a maximum, and passes off as gradually. These would appear to be conditions very favourable to the production of good definition.

Cambridge Observatory, Nov. 8, 1860.

Dévéloppement de la Fonction Perturbatrice en Série.

Par M. Kowalski. (Abstract.)

If v, v' are the true anomalies, ω, ω' the distances of the pericentres from the mutual node, and if

$$v - v' + \omega - \omega' = \theta$$
$$v + v' + \omega + \omega' = \psi,$$

then the reciprocal of the distance of the two planets can be developed in the form

$$\frac{1}{\varrho} = \frac{1}{2} \Sigma \, Z_i^{\beta} \cos (i\vartheta + \beta\psi),$$

where i and β extend from $-\infty$ to ∞ and $Z_i^{-\beta} = Z_i^{\beta}$.

Moreover, if z, z' denote the mean anomalies, and if the general term of the development of $\frac{1}{\varrho}$ is represented by

$$X \cos (\varkappa z - i z' + \eta\omega - \eta'\omega'),$$

where X can be expressed as a definite integral involving the coefficient Z; viz. the general term of X is

$$= \frac{1}{\pi^2} \int_0^{\pi} \int_0^{\pi} Z_{i+q}^{\beta} \cos (\varkappa z - \eta v) \cos (i z' - \eta' v') \, dz \, dz',$$

and the value of the coefficient X is obtained by means of a series of transformations effected upon this definite integral. The memoir has been published in the *Récherches Astronomiques de l'Observatoire de Kasan*, 1859.

Minor Planets (63), (61), (62).

Since the discovery by M. Chacornac of Minor Planet (59), three new Minor Planets have been discovered. As referred to by M. Leverrier (*Comptes Rendus*, 16th Oct. 1860), these are:—

Minor Planet (60), discovered by Mr. Ferguson, at Washington, on the night of the 15th Sept. The observed place was approximately,

	Washington M.T.	R.A.	N.P.D.
1860, Sept. 15	$10^h\,22^m\,5^s$	$23^h\,4^m\,30^s{\cdot}4$	$93^\circ\,23'\,39''$

Daily motion $-54^s{\cdot}0$ in Right Ascension and $9'{\cdot}0$ in North Polar Distance. It was noted on the night of the 14th as one not on Chacornac's Charts; and on the 15th its planetary character became evident. Estimated magnitude 11.

Minor Planet (61), discovered by M. Goldschmidt on the 9th Sept., and recognised as a Planet on the 19th. See last Number of the *Monthly Notices*, where this Planet is referred to as Minor Planet (60). The name *Danaë* has been given to it.

Minor Planet (62), discovered at Berlin by Dr. Forster and M. Lesser. First observed the 14th Sept., but supposed to be M. Chacornac's Planet (59). The continuation of the observations up to the 10th Oct. showed that the Planet was really a distinct one. Estimated magnitude 11. Elements calculated

by MM. Romberg and Tietjen, from the Berlin Observations of the 14th and 24th Sept. and 8th Oct. 1860, (see *Ast. Nach.* No. 1281, where there is also given a slightly different set of elements calculated by Dr. Seeling of the Glasgow Observatory).

Epoch, 1860, Sept. 24,51684.

Mean longitude	334° 55′ 19″	
Excentricity	9 25 52	
Longitude of perihelion	40 11 4	Mean Equinox of 1860·0.
Longitude of node	126 56 45	
Inclination	2 14 15	
Diurnal motion	636″·320	
Log. mean distance	0,497554	

The name *Erato* has been given to this planet.

Discovery of a New Comet.

In Léverrier's *Bulletins* of the 25th and 26th Oct. is contained the intelligence of the discovery of a new comet by M. Tempel at Marseilles. The following approximate place is given by M. Villarceau in the *Bulletin* of the 26th Oct.

		R.A.	Decl.
	h m	h m s	° ′
Oct. 25	15 30 Paris	10 5 18	+ 31 26

MISCELLANEOUS INTELLIGENCE.

Mr. Norman Robert Pogson has been appointed Astronomer at the Madras Presidency.

Sir John Herschel has forwarded to one of the Secretaries a letter from Prof. Erman, of Berlin, which he desires to bring before the notice of the Society. The following is the substance of the letter in question:—

"The Prussian Government contemplate erecting a bust of Bessel on the outside of the University-buildings at Königsberg, where it will range with those of other celebrities. The sculptor, Herr Siemering, who has prepared the bust from existing representations of Bessel, wishes to obtain orders for a copy or copies of his work, which is suited for erection in a public place, and is regarded by Prof. Erman as a faithful likeness. At his request, Prof. Erman has forwarded a photograph taken from the original to Sir J. Herschel, desiring

him to bring H. Siemering's proposal before English astronomers, and to say, at the same time, that copies on a reduced scale can be supplied if desired. The original bust is about double life-size. The photograph can be seen at the apartments of the Society."

Address, Herr Bildhauer Siemering, durch H. Geheim Ober-Baurath Stüber, Berlin.

To be sold:—

1. Gregorian reflecting telescope, with 6-inch speculum, on firm iron stand, with equatoreal motion, three eye-glasses ranging in power from 120 to 600.

2. Newtonian reflecting telescope, with 11-inch speculum, on firm iron stand, with two eye-glasses.

For further information, apply to the Assistant-Secretary.

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